

CLAIMS

1. A method for determining the location coordinates  
5 (x, y, z) of a mobile terminal (MS) with respect to a set of reference elements (SRB1,....., SRBn; Sat1, ..., Satm) adapted to send towards said mobile terminal (MS) radioelectric signals, the method including the steps of:

- 10       - measuring said radioelectric signals to derive respective measurements ( $\bar{y}_k$ ), said measurements ( $\bar{y}_k$ ) being affected by measurement errors,  
          - subjecting such measurements ( $\bar{y}_k$ ) to state-based statistical filtering ( $x_{k+1}$ ,  $y_{k+1}$ ,  $z_{k+1}$ ) to derive  
15 therefrom said location coordinates,

characterized in that it includes the steps of:

- selecting at least part of said set of reference elements as terrestrial reference elements (SRB1,....., SRBn), and  
20       - providing in said statistical filtering at least one further state ( $t_k$ ) in addition to said coordinates, said at least one further state ( $t_k$ ) being representative of said measurement errors.

2. The method of claim 1, characterized in that  
25 said statistical filtering is Kalman filtering.

3. The method of claim 1, characterized in that it includes the step of associating with said respective measurements at least one additional measurement (A) indicative of at least one of the location and  
30 displacement of said mobile terminal (MS).

4. The method of claim 3, characterized in that it includes the step of measuring an altitude coordinate (z) of said mobile terminal (MS).

5. The method of claim 1, characterized in that it  
35 comprises the step of including in said set of

reference elements at least one satellite of a satellite-based positioning system (Sat1, ..., Satm).

6. The method of claim 1, characterized in that measuring said radioelectric signals includes the step  
5 of determining at least one parameter selected from the group consisting of: power received at said mobile terminal (MS) from said set of reference elements, timing advance (TA), round trip time (RTT), observed time differences (OTD), and observed time differences  
10 of arrival (OTDOA).

7. The method of claim 1, characterized in that it includes the step of selecting at least part of said set of reference elements as elements (SRB1, ..., SRBn) comprising, together with said mobile terminal (MS), a  
15 terrestrial cellular communication system.

8. A method for determining the location coordinates (x, y, z) of a mobile terminal (MS) with respect to a set of reference elements (SRB1, ..., SRBn; Sat1, ..., Satm) adapted to send towards said mobile  
20 terminal (MS) radioelectric signals, the method including the steps of:

- including in said set of reference elements both terrestrial reference elements (SRB1, ..., SRBn) and at least one satellite of a satellite-based positioning  
25 system (Sat1, ..., Satm),

- measuring said radioelectric signals to derive respective measurements ( $\bar{y}_k$ ), said measurements ( $\bar{y}_k$ ) being affected by measurement errors,

- subjecting said measurements ( $\bar{y}_k$ ) to state-based  
30 statistical filtering ( $x_{k+1}$ ,  $y_{k+1}$ ,  $z_{k+1}$ ) to derive therefrom said location coordinates, and

- associating with said respective measurements at least one additional measurement (A) indicative of at least one of the location and displacement of said  
35 mobile terminal (MS).

9. A system for determining the location coordinates (x, y, z) of a mobile terminal (MS) with respect to a set of reference elements (SRB1, ..., SRBn; Sat1, ..., Satm) adapted to send towards said mobile terminal (MS) radioelectric signals, the system including:

- at least one measuring module (T, S) for measuring said radioelectric signals and deriving respective measurements ( $\bar{y}_k$ ), said measurements ( $\bar{y}_k$ ) being affected by measurement errors,
- at least one processing module (PCF1, PCF2) adapted for subjecting such measurements ( $\bar{y}_k$ ) to state-based statistical filtering ( $x_{k+1}$ ,  $y_{k+1}$ ,  $z_{k+1}$ ) to derive therefrom said location coordinates,

characterized in that:

- at least a part of said set of reference elements are terrestrial reference elements (SRB1, ..., SRBn), and
- said at least one processing module is configured (PCF1, PCF2) for including in said statistical filtering at least one further state ( $t_k$ ) in addition to said coordinates, said at least one further state ( $t_k$ ) being representative of said measurement errors.

10. The system of claim 9, characterized in that said statistical filtering is Kalman filtering.

11. The system of claim 9, characterized in that it includes at least one measurement source (AMS, 203) providing at least one additional measurement (A) to be associated with said respective measurements, said at least one additional measurement (A) being indicative of at least one of the location and displacement of said mobile terminal (MS).

12. The system of claim 11, characterized in that it includes an altimeter (AMS) for measuring an altitude coordinate (z) of said mobile terminal (MS).

13. The system of claim 9, characterized in that said set of reference elements includes at least one

satellite of a satellite-based positioning system (Sat1, ..., Satm).

14. The system of claim 9, characterized in that said at least one measuring module (T, S) is configured for determining at least one parameter selected from the group consisting of: power received at said mobile terminal (MS) from said set of reference elements, timing advance (TA), round trip time (RTT), observed time differences (OTD), and observed time differences of arrival (OTDOA).

15. The system of claim 9, characterized in that at least part of said set of reference elements (SRB1, ..., SRBn) comprises, together with said mobile terminal (MS), a terrestrial cellular communication system.

16. The system of claim 15, characterized in that at least one of said measurement module and said processing module includes a first portion (PCF1) hosted by said mobile terminal (MS) and a second portion (PCF2) hosted by a location center (MLC), wherein said first (PCF1) and second (PCF2) portions are arranged for data exchange over said terrestrial cellular communication system (CA)

17. A system for determining the location coordinates (x, y, z) of a mobile terminal (MS) with respect to a set of reference elements (SRB1, ..., SRBn; Sat1, ..., Satm) adapted to send towards said mobile terminal (MS) radioelectric signals, the system including:

- both a set of terrestrial reference elements (SRB1, ..., SRBn) and at least one satellite of a satellite-based positioning system (Sat1, ..., Satm) as said reference elements,

- at least one measuring module (T, S) for measuring said radioelectric signals to derive respective

measurements ( $\bar{y}_k$ ), said measurements ( $\bar{y}_k$ ) being affected by measurement errors,

- at least one processing module (PCF1, PCF2) for subjecting said measurements ( $\bar{y}_k$ ) to state-based statistical filtering ( $x_{k+1}$ ,  $y_{k+1}$ ,  $z_{k+1}$ ) to derive therefrom said location coordinates, and

- at least one measurement source (AMS, 203) providing at least additional measurement (A) to be associated with said respective measurements, said at least one additional measurement (A) being indicative of at least one of the location and displacement of said mobile terminal (MS).

18. A mobile terminal (MS) configured for determining its location coordinates ( $x$ ,  $y$ ,  $z$ ) with respect to a set of reference elements (SRB1, ..., SRBn; Sat1, ..., Satm) adapted to send towards said mobile terminal (MS) radioelectric signals, the terminal including:

- a measuring module (S, T) for measuring said radioelectric signals and deriving respective measurements ( $\bar{y}_k$ ), said measurements ( $\bar{y}_k$ ) being affected by measurement errors,

- a processing module (PCF1) adapted for subjecting such measurements ( $\bar{y}_k$ ) to state-based statistical filtering ( $x_{k+1}$ ,  $y_{k+1}$ ,  $z_{k+1}$ ) to derive therefrom said location coordinates,

characterized in that:

- the terminal (MS) constitutes, together with at least part of said set of reference elements (SRB1, ..., SRBn), a terrestrial communication system, and

- said processing module (PCF1) is configured for including in said statistical filtering at least one further state ( $t_k$ ) in addition to said coordinates, said at least one further state ( $t_k$ ) being representative of said measurement errors.

19. The terminal of claim 18, characterized in that said statistical filtering is Kalman filtering.

20. The terminal of claim 18, characterized in that it has associated at least one measurement source (AMS, 5 203) providing at least one additional measurement (A) to be associated with said respective measurements, said at least one additional measurement (A) being indicative of at least one of the location and displacement of said mobile terminal (MS).

10 21. The terminal of claim 20, characterized in that it has associated an altimeter (AMS) for measuring an altitude coordinate (z) of the mobile terminal (MS).

22. The terminal of claim 20, characterized in that it is mounted on a vehicle (V), and in that said at 15 least one additional measurement (A) being indicative of at least one of the location and displacement of said vehicle (V).

23. The terminal of claim 18, characterized in that said measuring module is configured for determining at 20 least one parameter selected from the group consisting of: power received at said mobile terminal (MS) from said set of reference elements, timing advance (TA), round trip time (RTT), observed time differences (OTD), and observed time differences of arrival (OTDOA).

25 24. A mobile terminal (MS) configured for determining its location coordinates (x, y, z) with respect to a set of reference elements (SRB1, ..., SRBn; Sat1, ..., Satm) adapted to send towards said mobile terminal (MS) radioelectric signals, said set of 30 reference elements including both terrestrial reference elements (SRB1, ..., SRBn) and at least one satellite of a satellite-based positioning system (Sat1, ..., Satm), the terminal including:

- a measuring module for measuring said 35 radioelectric signals to derive respective measurements

( $\bar{y}_k$ ), said measurements ( $\bar{y}_k$ ) being affected by measurement errors,

- a processing module (PCF1) for subjecting said measurements ( $\bar{y}_k$ ) to state-based statistical filtering
- 5 ( $x_{k+1}$ ,  $y_{k+1}$ ,  $z_{k+1}$ ) to derive therefrom said location coordinates, and
- at least one measurement source (AMS, 203) associated to the mobile terminal (MS) and providing at least one additional measurement (A) to be associated
- 10 with said measurements, said at least one additional measurements (A) being indicative of at least one of the location and displacement of said mobile terminal (MS).

25. A computer program product loadable in the memory of at least one computer and comprising software

15 code portions for performing the method of any of claims 1 to 8.

26. A computer program product loadable in the memory of a computer and including software code portions for implementing the mobile terminal of any of

20 claims 18 to 24.